The Design and Evaluation of a Text Editing Technique for Stylus-Based Tablets

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Abstract

We describe the design and evaluation of a technique aimed at improving text editing on touchscreen devices that exploit the use of stylus-based gestures. The technique has been designed by choosing the most natural gestures for users, established in a preliminary study. The technique allows the user to interact directly with the text to perform commands such as select, move, copy, delete and paste. We conducted an experiment to compare the gestural editing technique to the classical technique (present on Android devices). Results show an advantage in terms of efficiency for the gestural technique with large font.

Keywords: *Gestures; Text editing; Stylus tablet; Touchscreen.*

1 Introduction

Mobile touchscreen devices such as smartphones and tablets are becoming ever more popular in recent years. These devices are used to perform a wide range of operations: web browsing, chatting, reading documents, etc. With the proliferation of touchscreens, the research has focused on improving user interaction with them. At the end of the 60s, Coleman was one of the first authors to study the use of handwritten symbols for text-editing [8]. Other studies dealt with text-processing [17] and sketch-editing [6]. In view of this research, there are increasingly common applications that take advantage of gestures to facilitate some operations. A gesture is a sign made by hand (e.g. a circle, an arrow, etc.) possibly used to denote a command.

A suitable application for gesturing is text editing. While on a classic personal computer mouse/touchpad, keyboard and WIMP-based interfaces are used to perform editing operations with reasonable efficiency, text editing can be particularly difficult on mobile touchscreen devices. In fact, the screen size can create additional obstacles: the use of a finger as a pointing device introduces problems of accuracy and occlusion (only partially solved by using a stylus). Additionally, it is not possible to use keyboard shortcuts (because a physical keyboard is typically absent).

For the reasons mentioned above, text editing is not a very common task on mobile devices. Text editing on a touchscreen is currently performed through a *Widget-based* technique. Typically, the user enters text using a soft keyboard (or handwriting) and moves the cursor by simply tapping with his/her finger on the desired point of the text. Besides entering new text, the user may perform selection and editing operations by using the widgets that appear in a menu over the text after a user interaction (e.g. a long press). In this context, the use of gestures could facilitate this task, for example, a user may delete a word by simply performing a specific gesture (e.g. a cross) over it.

The aim of this paper is to design a new text editing technique based on gestures, which allows performing the main operations in a simple and intuitive way. In order to identify the most natural gestures for text editing, a preliminary exploratory study was carried out. The set of tasks was defined by analyzing some papers on the same topic, including [18, 15, 24]). Starting from the data collected through this preliminary study, we identified the most appropriate gestures for each editing operation. The user can perform them directly on the text, thus making the editing technique independent from the text entry method (e.g. a soft keyboard). This way the user may choose any input method, depending on the context and its preferences, including keyboards that make use of gestures [19, 12, 11, 14].

This paper is organized as follows: Section 2 describes some works related to ours; Section 3 describes the preliminary experiment regarding user preferences on gestural text editing; Section 4 describes the proposed text editing technique and Section 5 its experimental evaluation. A discussion on the limitation of this study and some comments on future work conclude the paper.

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2 Related Work

The introduction of touchscreen has led to the study of new forms of interaction. One of the first metaphors used was to simulate the use of paper, for example to allow drawing of figures or diagrams [1, 16, 9, 10]. Beyond this simple form of interaction, much research in the HCI field has focused on the use of gestures to perform actions. Most of it developed before the rise of finger pointing and multi-touch gestures (e.g. [24, 22]) and was based on the slower but more precise stylus/mouse. Bragdon et al. [4] discovered that in the presence of distractions, the use of gestures to issue commands improves performance w.r.t. the use of touch buttons (such as a QWERTY keyboard). The reason is that using gestures requires less attention than using widgets since in the latter case the user has to look at the keys before touching them. Moreover, when dealing with shortcuts, users tend to remember gestures better than keyboard shortcuts and make fewer mistakes [2].

Findlater et al. [12] pointed out another aspect of the usefulness of gestures. In particular, their study focused on writing non-alphanumeric input using gestures on touchscreen devices equipped with QWERTY soft keyboards. The advantage of this technique is that people do not need to change the interface to enter symbols that are not letters and numbers. The results showed an overall favor for this technique over moded-keyboard interfaces.

Text editing research had its climax at the time of the first graphical user interfaces, starting from the cut/copy-paste technique developed since the 1970s. Text editors have become increasingly complex, leading to studies on the new features [3, 20, 21]. In the literature, there are a few works discussing text editing with gestures on mobile devices. Some works only focus on a single editing function. Chen et al. [7] focus instead on the Copy-Paste operations, that are not as easy to perform on smartphones as on desktop computers. They propose BezelCopy, a copy-paste technique based on bezel-swipe gestures, and evaluate it showing that it outperforms alternative approaches for a number of commonly performed copy-paste tasks. Scheibel et al. [23] focus on the problem of precise pointing on touchscreens, proposing a virtual stick controller technique and evaluate it in a text editing context showing that it may facilitate the placing of the cursor when the font size is small.

Many commercial applications face the same problem with different solutions. In Apple iOS, a magnifying glass appears on the touched text after a long press. Then the user can move his/her finger on the magnified area and the view is updated in real time. This technique avoids the problem of occlusion and allows to correctly position the cursor even if the text has a very small font. Android implements a graphical widget attached to the lower end of the cursor. The widget can be moved with the finger, partially solving the problem of occlusion, but it is not very practical for small fonts and does not offer magnification. Moreover, many soft keyboards offer cursor movement with the help of arrows on the keyboard, e.g. the Hacker's Keyboard[1] and the Arrows Keyboard[2].

Fuccella et al. [15] compare a gesture-based editing technique to a widget-based one. The results show a performance improvement of 13-24% for the gesture technique. The feedback from the participants was also positive. Moreover, the two editing techniques use different input channels, so they can co-exist on a single device. This means that gestural editing can be added to any soft keyboard without interfering with the experience of the user that chooses not to use it.

There are several studies in the literature that evaluate the performance of text editing. The above-mentioned papers include the evaluation of editing techniques on touchscreen devices. Older works, however, have a different focus, such as Wolf and Morrel-Samuels [24] that conducted an experiment on pen and paper for simple text-editing tasks. The purpose of this study was to analyze the consistency and frequency of gestures for editing operations. This experiment was performed with 12 participants and was divided into three phases. In the first phase, participants had to choose a gesture for each task and perform the editing operations. The second phase was repeated immediately after the first one and the participants had to use their chosen gestures again; the last phase, equal to the previous one, was performed after a week. The feedback from participants was positive as shown by answers to a questionnaire: 85% said it had carried out the task of editing without having to think too much about the gesture to use, 69% said that it seemed natural to use gestures and 77% easily remembered previously performed gestures.

3 Preliminary experiment

The aim of this preliminary experiment is to find the most suitable set of gestures for editing text on the basis of users' preferences. This study takes inspiration from the work of Wolf and Morrel-Samuels [24] described in Section 2, with the difference being that in our case the tasks are performed on a touchscreen instead of on a paper.

3.1 Participants

We recruited 10 participants (3 female) between 19 and 25 years old (M=22.9, SD=2.13). All of them were university students who agreed to participate for free. All participants had experience with touchscreen devices and 9 of them also with their use with a stylus.

[1] http://code.google.com/p/hackerskeyboard/

[2] http://arrows-keyboard.android.informer.com/

3.2 Apparatus

The experiment was carried out on a Huawei P8 smartphone running Android 5.0.1. The device has a 5.2” touchscreen which can be operated with both finger and a stylus.

The experimental software was developed in Java in order to allow execution and recording of editing tasks. It consisted of an Android application, showing at the top the description of the requested text editing operation and some text below, with the parts to be edited highlighted in green. The gestures performed by the user are shown over the text as red lines in order to provide a feedback. Since our goal is just to record the gestures, the gestures produce no effect on the text. A *Next* button at the bottom right of the screen allows the user to advance to the next task. For each completed task the software logs the data of the user gestures as a list of (*x, y, time*) tuple and a screenshot of each of them.

3.3 Procedure

Before starting the experiment, participants had an introductory phase where the experimental procedure was briefly explained and some demo tasks were shown. Then they were asked to fill out a pre-experiment questionnaire with the following information: personal data (age, gender); handedness (right-handed, left-handed); previous experience with touchscreen devices (tablets, smartphones, etc.) whether they had experience using a stylus.

After that, each participant was asked to perform the editing tasks proposed by the application, following the shown task descriptions. There was no time limit. We selected thirteen different editing tasks: split word, delete character, select phrase, delete paragraph, delete phrase, delete word, insert character, enter a word, join text, move row, move phrase, move word and select text. Each task was presented twice to each participant, for a total of 26 tasks. The tasks were presented sequentially in a random order.

At the end, a questionnaire was given to each participant to collect information and opinions.

3.4 Design

The experiment was a within-subjects design. The independent variable was the task, with 13 test condition. The dependent variables were 2: the gesture and the task completion time.

The screenshots recorded for each task were analyzed by a human operator in order to classify the editing gesture(s) made by the participant. Since 10 participants performed 13 tasks, each of them twice, $10 \times 13 \times 2 = 260$ screenshots were analyzed to identify the gestures.

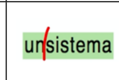
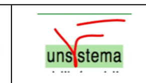
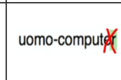
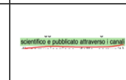
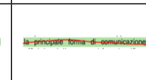
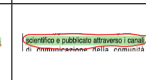
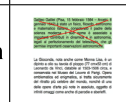
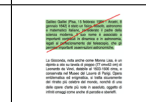
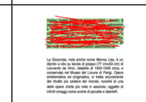
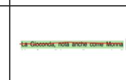
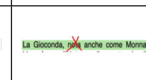
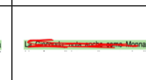
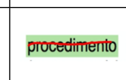
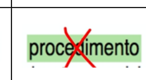
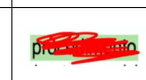
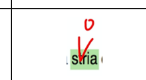
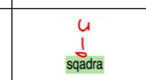
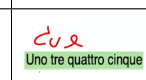
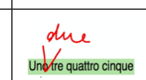
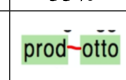
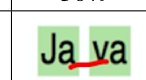
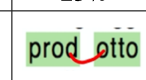
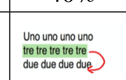
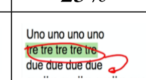
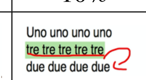
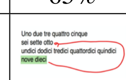
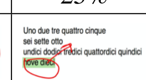
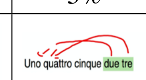
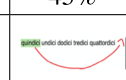
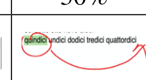
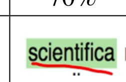
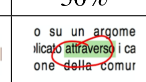
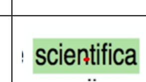
Task	**Gestures**			**Other**
split word	 90%	 10%		0%
delete character	 45%	 40%	 10%	5%
select phrase	 75%	 15%	 10%	0%
delete paragraph	 70%	 20%	 10%	0%
delete phrase	 60%	 30%	 10%	0%
delete word	 50%	 30%	 10%	10%
insert character	 65%	 25%	 10%	0%
enter a word	 35%	 30%	 25%	10%
join text	 40%	 25%	 10%	25%
move row	 65%	 25%	 5%	5%
move phrase	 45%	 30%	 25%	0%
move word	 70%	 30%		0%
select text	 55%	 25%	 20%	0%

Table 1: Gestures classes used by the participants to complete each task and their frequency.

3.5 Results and discussion

All participants completed the experiment. Except for introduction and questionnaires, the mean experiment completion times among the participants was 202 seconds (SD=56).

For each task, the gestures used by the participants were identified. Table 1 shows each gesture class frequency (as a percentage) and a gesture example (taken from the experiment screenshots).

It is worth noting that only for a subset of the tasks was it possible to clearly identify a gesture preferred by the participants. In fact, for some tasks, the participants split between different alternatives. An example in which almost all of the participants used the same gesture is the *"split word"* task (9 out of 10 participants performed the same gesture). There was no consensus, instead, for example for the *"delete character"* task.

The final questionnaire indicated that none of the participants spent much effort in thinking of a possible gesture to complete the task, and that in the second trial of a task most of the participants remembered the gesture performed the first time.

4 Design of the Gestural Editing Technique

We designed our text editing technique on the basis of the data collected in the above-described preliminary study. The selection of the set of editing features supported through gestures also took into account the work of Roberts [20]. For most editing actions we selected the first or second most frequent gesture resulting from the previous experiment, taking into account the need to remove the ambiguity between different selected gestures. For the editing actions requiring the entry of some text, we decided not to rely on any specific input method (e.g. handwriting), but to rely on the default system method (usually a soft keyboard). Moreover, in order to support typical text editor operations, gestures for operations like *copy, paste, cut, undo and redo* were added.

The set of supported editing features and related gestures are shown in Table 2. The *Gesture* column shows how the gesture is performed on the text, while the *Explanation* column describes the functionality implemented by that gesture. Every gesture begins with a dot (in red), continues with a line (in black) and ends with an arrowhead (in red). This notation shows all the movements of the stylus from pressure to release, with the arrow indicating the gesture direction. The gesture set can be divided into three categories:

- *deletion*: gestures indicating the deletion of text (individual characters or one or more consecutive words). To delete a character the user can simply draw a diagonal line (slash) over the character to be deleted. To

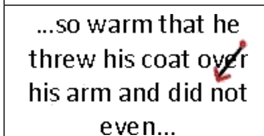
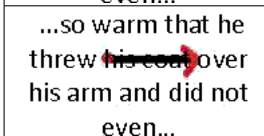
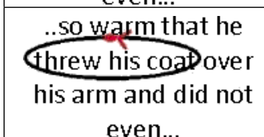
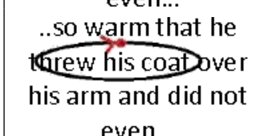
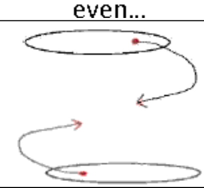
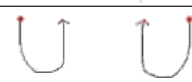
Gesture(s)	**Explanation**
	The character underneath the gesture will be deleted.
	The text underneath the gesture will be *cut* (deleted and copied in the clipboard).
 	The text enclosed within the outlined area will be selected (and highlighted).
	The text selected by enclosing it within the outlined area will be moved to the point where the second gesture ends.
	*Paste* the text from the clipboard (if present) at the place where the cursor is currently placed.
	*Copy* the selected text into the clipboard.
	*Undo* the last performed editing operation (if there is one).
	*Redo* the last operation that has been undone (if there is one).

Table 2: Gesture set implemented by the gestural editing technique. Gesture starts are shown as a red dots, gesture ends as red arrowheads.

delete one or more words, s/he can draw a horizontal line that covers the portion of text to be deleted. If more than half of a word is covered, it will be fully deleted. Word deletion also performs the *cut* functionality, i.e. the deleted text is inserted in the clipboard.

- *moving/copying*: gestures allowing text movements. There are two ways to perform such operations: *cut-paste* and *select-move*. In the former, the user first deletes some text, then places the cursor at the desired point and performs a *paste* function. The deletion is performed as specified at the previous point. The paste operation is performed through a `P` gesture. In the latter, the user first selects some text by drawing an ellipse around it. This highlights the selected text and allows the user to drag it by tracing a line starting from the highlighted area and ending in the place in which the text should be moved. The selected text remains in place and it is moved to its final location only when the gesture ends. Finally, to only copy a piece of text, without cutting or moving it, the user can select it as above and then perform the `C` gesture. To paste the copied text, the same procedure used for the *cut-paste* is used, i.e. placing the cursor and performing the `P` gesture.

- *editing correction*: to correct editing errors, the user can perform the `U` undo gesture. To redo the editing operation that was incorrectly invalidated with an undo, the user may simply perform the `R` gesture.

In order to perform the gesture recognition, the PolyRec [13] gesture recognition method was used.

5 Experiment

To check the effectiveness of the proposed technique, we compared it to one of the standard text editing techniques for mobile devices. In particular, we compared it to the standard text editing technique available on the Android system. During the experiment, we collected information about the user performance in carrying out the proposed editing tasks.

5.1 Participants

For the experiment, 12 participants (5 female) between 21 and 30 years old (M=24.17, SD=2.58) were recruited. All of them were university students who agreed to participate for free, with no overlap with the participants of the experiment described in Section 3.

All of them already had experience with touchscreen devices, using their smartphones every day. They were asked how frequently they perform text editing operations on touch devices, and we found that text editing is rarely performed, except for a single participant who declared to perform it frequently to send emails and messages.

All the participants declared an average knowledge of the English language. We considered this level sufficient to perform editing tasks (of English text).

5.2 Apparatus

The experiment was carried out on a Mediacom tablet running Android 4.4.2. The touchscreen display has a size of 10.1” and a resolution of 1366x768 pixels. A simple capacitive stylus was used to interact with the device.

The experimental software is an Android application showing a list of all the tasks to be performed. By tapping on one item, the corresponding task is launched in an editing view. After the user completes a task, its entry in the list is highlighted. The editing view uses either the traditional editing widget (EditText Android widget) or the gestural editing technique (a custom version of the Android TextView widget). A task is not considered completed if the text still contains errors. Nevertheless, the user had the option to abandon a task (e.g. if the text had been irreparably changed). In this case, the task was reset and restarted.

The software records all major user actions and calculates the completion time of each task. The task is considered completed when the current text equals the text defined in the task solution. At task completion, an *Android toast* with the completion time is shown to the user.

5.3 Procedure

Before starting the experiment the participants were asked to fill out a form with the following information: age, gender, English knowledge level, experience level with touchscreen devices and with text editing on such devices. Then they received an explanation of the experimental procedure and were given an instruction sheet, containing a table with the set of allowed gestures (in gestural editing mode) and a table with the task list (including the initial text and correct text). The sheet was left with the user throughout the whole experiment.

The experiment started after the experimenter ascertained that the participant had well understood the procedure. The experiment consisted of seven tasks in which the user had to correct the given text, each one repeated for the two editing techniques. The experiment was divided into four blocks. The first block was used as user training (not recorded) and performed with the medium font size. Half the users first used the gestural editing technique and then the classic technique, while the other half followed the reverse order. The other three blocks composed the actual experiment, each one with a different font size (small, medium, large).

Task	Title	Description	Presented Text	Final Text
1	Delete character	Delete the **X** characters from the text	It was a lovely night, so war**X**m that he threw his coat over his arm and did not even put his silk scarf round his throat. As he stro**X**lled home, smoking his. . .	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his. . .
2	Delete word		It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf **XXXXXX** round his throat. As he strolled home, smoking his. . .	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his. . .
3	Delete phrase		It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he **XXXXX XXXXX** strolled home, smoking his. . .	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his. . .
4	Move word (cut - paste)	Move the highlighted words in the correct position (shown as a vertical bar)	It was a lovely night, so warm that he threw his coat over his arm and did not| even **put** his silk scarf round his throat. As he strolled home, smoking his. . .	It was a lovely night, so warm that he threw his coat over his arm and did not put even his silk scarf round his throat. As he strolled home, smoking his. . .
5	Move word (select - move)		It was a lovely night, so warm that he threw his coat over his arm and did not| even **put** his silk scarf round his throat. As he strolled home, smoking his. . .	It was a lovely night, so warm that he threw his coat over his arm and did not put even his silk scarf round his throat. As he strolled home, smoking his. . .
6	Move phrase	Move the highlighted phrases in the correct position	He **of them** heard one| whisper to the other, "That is Dorian Gray." He **used to be when** remembered how pleased he| he was pointed out, or stared at, or talked about. . .	He heard one of them whisper to the other, "That is Dorian Gray." He remembered how pleased he used to be when he was pointed out, or stared at, or talked about. . .
7	Text correction	Fix the text	It was a lovely night, so war**X**m that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him. He heard one of them whisper to the other, "That **XXXX** is Dorian Gray." He remembered how pleased he used to be when he was pointed out, or stared at, or talked about. He was tired of hearing his own name now. Half the charm of the| village where he had **little** been so often lately was that no one knew who he was.	It was a lovely night, so warm that he threw his coat over his arm and did not even put his silk scarf round his throat. As he strolled home, smoking his cigarette, two young men in evening dress passed him. He heard one of them whisper to the other, "That is Dorian Gray." He remembered how pleased he used to be when he was pointed out, or stared at, or talked about. He was tired of hearing his own name now. Half the charm of the little village where he had been so often lately was that no one knew who he was.

Table 3: Editing task list (in order to reduce table size, the task texts are only partially shown).

The given tasks are shown in Table 3. They were designed using [15] as the base, and considering the most significant task for the main editing operations that can be performed (at least partially) with gestures using our technique. The tasks can be divided into two main groups, depending on the predominant type of operation within them (in the gestural editing mode). The first group is formed by delete-intensive tasks (1, 2, 3); the second one is composed of move-intensive tasks (4, 5, 6), while task 7 is a mixed task. The first group can be performed with direct gestures: it is, in fact, possible to perform a single gesture to complete the operation. The second group, instead, can only be performed with multiple gestures.

After the end of the experiment, participants were asked to fill out a System Usability Scale (SUS) questionnaire [5] for each of the two editing techniques. The SUS questionnaire consists of 10 statements to which the user assigns a score on a scale from 1 (strongly disagree) to 5 (strongly agree). The final score of the SUS ranges from 0 to 100. A higher score indicates a greater user usability. Moreover, after the experiment, user free form comments and suggestion were also collected. In particular, at the end of the questionnaire, there was a blank space where each participant could write his/her comments and suggestions about the techniques and a checkbox to state if s/he would like to use the technique in everyday life.

5.4 Design

The experiment was a two-factors within-subjects factorial design. The factors were the text font size (4.0, 5.5 and 7.0 mm) and the editing technique (gesture, traditional). The font sizes were selected by considering 5.5 mm a comfortable size, and adding two more dimensions (one greater by 1.5 mm and one smaller by the same extent). The order of editing technique and font size was counterbalanced between participants, as shown in Table 4.

The dependent variables were the overall task completion time (given by the sum of the 7 task completion times) and the number of failed tasks.

To evaluate user satisfaction the SUS was used for both editing techniques.

6 Results

All participants completed the experiment. The experiment took each of them about half an hour. We tested for significance using a repeated measures analysis of variance (ANOVA). For significant main effects, we used Bonferroni-Dunn post-hoc tests. The alpha level was set to 0.05.

The overall task completion times grouped by font size are shown in Figure 1. As it can be seen, for medium and

Participant	*Font size order*		*Editing technique order*
	Training	*Blocks*	
1	m	s-m-l	gesture - classic
2	m	s-l-m	gesture - classic
3	m	l-s-m	gesture - classic
4	m	l-m-s	gesture - classic
5	m	m-s-l	gesture - classic
6	m	m-l-s	gesture - classic
7	m	s-m-l	classic - gesture
8	m	s-l-m	classic - gesture
9	m	l-s-m	classic - gesture
10	m	l-m-s	classic - gesture
11	m	m-s-l	classic - gesture
12	m	m-l-s	classic - gesture

Table 4: Counterbalancing used during the experiment. Font size abbreviated (s - small, m - medium, l - large).

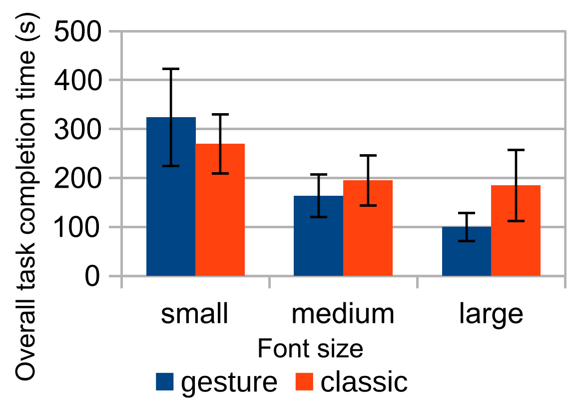


Figure 1: Mean overall task completion time for the two editing techniques, grouped by font size. Error bars show the standard deviation.

large font sizes the users were faster with the gestural editing technique (163" vs 195" for medium size, 100" vs 185" for large size), while for small font size they were faster with the traditional technique (324" vs 270"). This is due to the fact that the small font requires greater precision when performing the gestures, and with the capacitive stylus, it is not always easy to work on a small amount of space. Globally the gesture method is sightly faster (196" vs 216").

From the ANOVA resulted that there was no significant effect of the editing technique ($F_{1,11} = 2.258$, $p = .1611$). The main effect of the font size on the overall task completion time was highly significant ($F_{2,22} = 68.682$, $p < .0001$). The interaction effect between the two factors was also statistically significant ($F_{2,22} = 10.887$, $p = .0005$). A Bonferroni-Dunn post-hoc test revealed significant differences between Gesture-Large and Classic-Large (while no significance was sought between Gesture-Small and Classic-Small, Gesture-medium and Classic-Medium).

The mean completion times for each task are shown in Figure 2. We report a separate chart for small (a), medium (b) and large (c) font and for their aggregated values (d). The gestural editing technique was almost always faster than the classic technique for the medium and large font sizes, with task 6 (*move phrase*) as the only exception for the medium font. The classic technique was instead almost always faster with small font, with the exception of task 2 (*delete word*) and task 3 (*delete phrase*).

Finally, it turned out that the participants failed fewer tasks with the gestural editing technique compared to the traditional editing technique. In particular, only one failed task occurred for the gestural technique (with small font size), while 6 failed tasks occurred for the traditional technique (4 with small font size and 2 with large font size). Nevertheless, the ANOVA results show no significant effects for the editing technique ($F_{1,11} = 2.570$, $p = .1372$), the font size ($F_{2,22} = 2.714$, $p = .0884$), or their interaction ($F_{2,22} = 0.865$, $p = .4348$).

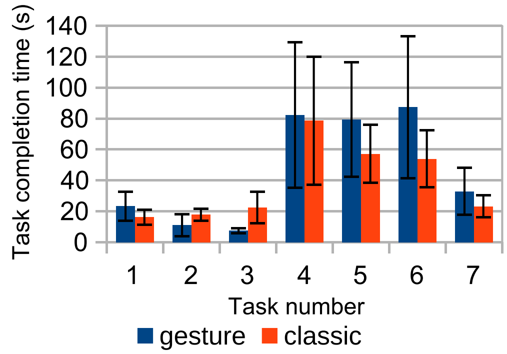
6.1 User Satisfaction and Free-form Comments

The average SUS score was 61.25 for the classic editing technique ($SD = 18.68$) and 73.13 ($SD = 15.88$) for the gestural editing technique. A Wilcoxon matched-pairs signed-ranks test performed on SUS scores revealed a statistical significance between the two techniques ($Z = -2.138$, $p < .05$).

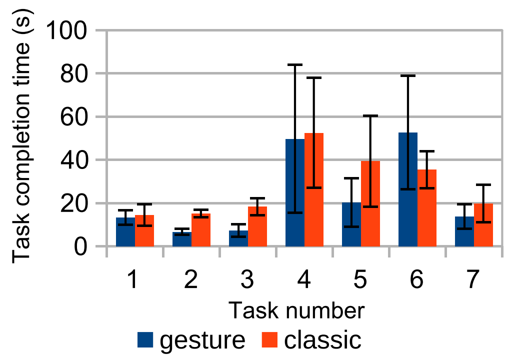
When asked which editing technique they prefer, all participant chose the gestural one, highlighting a greater ease in task execution with the possibility of omitting many actions. The only problem highlighted by all participants was the lack of usability with the small font size. Some users suggested fusing the two techniques in order to allow greater efficiency. The action that proved to be more complex for participants were those involving text moving, which requires a greater effort in some conditions. Regarding the traditional technique, some participants pointed out that it would be appropriate to add an *Undo* button, to limit the cases in which it is necessary to restart a task.

6.2 Discussion

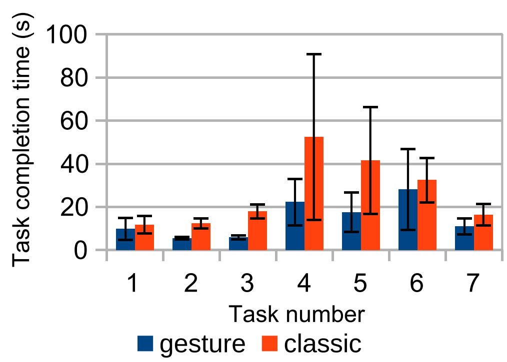
During the experiment, the participants could consult the sheet with the gesture set supported by the gestural editing mode, while in a real context this guide would not be available. A further study will be needed to understand how easy it is for the users to learn the gesture set and how useful the addition of an interactive help would be. However, from participants' comments and results, the gesture set seemed quite easy to learn and use, as expected since their choice is based on the results of the preliminary study. There was no consensus among participants in choosing the best ges-



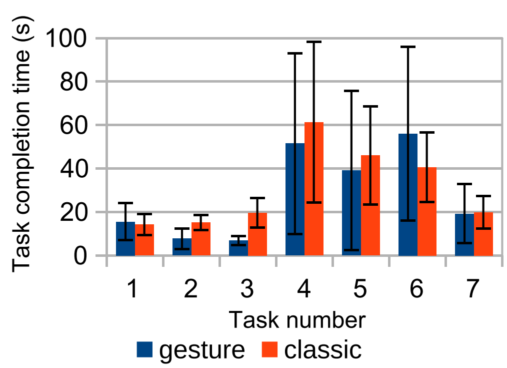
(a) Small font mean task completion times.



(b) Medium font mean task completion times.



(c) Large font mean task completion times.



(d) Mean task completion times (mean for all font sizes).

Figure 2: Task completion times. Error bars show the standard deviation.

ture sequence to move text: about 50% of them preferred to cut-paste while the other 50% preferred select-move. This reflects their preference when operating on a touch device. However, on average, select-move is faster than cut-paste, as can be seen by looking at tasks 4 and 5 in Figure 2.

Some participants also complained about cursor positioning. Especially with small font size, it was difficult for them to place the cursor quickly. This is a general issue found in text editing applications, and some techniques are used to improve the placing, as described in Section 2. Some participants suggested adding one of those techniques in order to allow a further efficiency increase. When assessing the results one must also consider that the participants already knew the traditional editing technique, while they had to learn the new gesture based technique. Despite this, all participants showed a fast learning process.

7 Conclusions and further works

This paper presents a new gesture-based text editing technique, which allows the user to perform operations such as text deletion and moving text more efficiently. The technique was designed by taking into account the most natural gestures for users, investigated through a preliminary study. A user study was also conducted to compare the proposed technique with the classical one. The results show that the gestural editing technique outperforms the traditional one when the text font size increases. The feedback about the gestural technique is positive, and participants showed that the gestures can be learned in a short time. Future work includes a refinement of the gesture set in order to allow greater user accuracy, particularly on small fonts. The participants' proposal to integrate a technique to facilitate cursor placement with small fonts can also be implemented. Lastly, the suggestions of fusing the gesture and classical techniques might also be considered, in order to allow increased user satisfaction and performance.

Future studies will also aim at mitigating the threats to the validity of this study, such as increasing the number of participants and testing with different device and stylus types.

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